

**WSDOT**  
**CATHODIC PROTECTION ASSESSMENT**

**I-90 BRIDGES  
LACEY V. MURROW  
&  
3rd LW BRIDGE**

**FOR**

**R.W. BECK & ASSOCIATES**

**OCTOBER 1993**



**EXPIRES: 12/01/ 93**

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**Intermountain Corrosion Service, Inc.**





## Intermountain Corrosion Service, Inc.

Lloyd Marquart  
R.W. Beck  
1501 25th Ave. South  
Seattle, WA 98144

October 27, 1993  
ICS - 0139

SUBJECT: Lake Washington I-90 Bridge Cathodic Protection Evaluation

Dear Lloyd,

A overview assessment of the recently activated cathodic protection systems installed for the LVM and 3rd Lake Washington bridges anchor cables was performed by Intermountain Corrosion Service, Inc. just prior to the September 12, 1993 opening of the LVM bridge. The purpose of the assessment was to identify the operating characteristics for the impressed current cathodic protection systems.

### DESCRIPTION OF STRUCTURES

A separate rectifier and anode(s) are installed for each existing anchor cable. The rectifiers are mounted inside the anchor gallery adjacent to the cable tunnel. The anodes are suspended vertically from supports mounted on the outside of the pontoon wall also adjacent to the cable tunnels. The majority of the systems are identical with some variation in anode length, rectifier size and rectifier manufacture.

Permanent Ag/AgCl reference cells are installed on two LVM cables. The cells are intended to facilitate testing at remote locations of the cable.

### TEST PROCEDURES

No electrical connections are shown to exist on any cable away from the pontoons. The 3rd Bridge North face cables have boater safety pontoons tied to the anchor cables but are not reported to be electrically isolated from the cable.

Seven of the thirty cables installed on the LVM bridge were selected. Each of the cables are representative of the various cable configurations along the length of the LVM and 3rd Bridge structures.

Structure-to-water potentials were measured at selected cables as identified in Tables I, through VII, with reference to a portable copper copper-sulfate reference electrode, and permanently

installed silver silver-chloride reference electrodes. Structure connections were made on each respective anchor cable near the rectifier. The portable reference electrode was placed in the water as near the cable as possible to insure accuracy.

Electrical continuity between subject cables and adjacent cables and structures was investigated.

## TEST RESULTS AND ANALYSIS

Final test results are presented in the attached Tables.

During the initial testing, it was suspected that an "IR Drop" error was biasing the potential measurements. The accuracy of test results was therefore being affected by potential field influence from adjacent cathodic protection system anode(s).

The cable-to-water potential values shown in Tables I, through VI indicate a definite influence on individual test cables from adjacent cathodic protection systems. As an example, the data presented in Tables I through IV indicate that the potential values of each of the cables tested are influenced by interrupting the cathodic protection systems of adjacent cables on the same bridge as well as opposite cables on the other bridge. Cables on both sides of a single pontoon, as well as, cables on opposite pontoons and bridges were tested similarly with adjacent and opposite cathodic protection systems interrupted.

Stray current interference could not be tested for due to the lack of a electrical contact test point some distance down the cable. Based on the test data gathered on five of the cables during this investigation, stray current interference still remains questionable. To absolutely rule out stray current interference as a detrimental condition, more testing would be required, and electrical contact point attached to the cables some distance down the anchor cables.

Due to the absence of an electrical contact test point on the pontoons, potential stray currents on the prestressing tendons and reinforcing steel could not be evaluated.

The data presented in Table VIII indicates a 10 fold variation in CP current densities across the structure. The data was expanded from test data supplied by R.W. Beck. The volts and amps were taken from a report submitted by Norton Corrosion, and the cable length taken from design drawings. The last column in the Table list the current density for all cables for both bridges. Theoretically, the current density for all cables should be nearly the same if the cables are the same diameter, are electrically isolated and the level of cathodic protection, as shown by structure-to-water potentials, is in the same range. Our test indicate that all cables tested, with the exception of A-Pontoon, are electrically isolated from all other structures.

Tests taken in the cable tunnel were inconclusive and will need to be evaluated with respect to native potentials.

The output of one rectifier was observed to increase with the interruption of an adjacent rectifier. This condition may be a problem but was not investigated.

## **CONCLUSIONS**

1. Cable-to-water potential test values are influenced by other cathodic protection systems and do not indicate the true or actual potential.
2. Based on the large variation in current densities, it appears some cables are under protected, while others are over protected, and may be resulting in stray currents on adjacent cables.
3. Anchor cables, with the exception of A-Pontoon are electrically isolated from other pontoon components.
4. Potential values in the cable tunnel must be re-tested and compared to native state potentials.

## **RECOMMENDATIONS**

1. Step I - Turn off all cathodic protection systems and allow the cables to depolarize.
2. Step II - Record native state potentials for use as baseline data for operating cathodic protection systems and to evaluate the need for supplemental cathodic protection within the cable tunnel. Measure electrical continuity between adjacent cables.
3. Step III - Select up to seven representative cables to be reactivated. Evaluate accuracy of recommended procedures for activation of all systems. Data collected in the native, ON, and polarized condition will be used as basis to confirm procedures necessary to accurately activate all systems.
4. Step IV - Reactivate all cathodic protection systems. To accurately adjust all individual cathodic protection systems, one system must be activated and adjusted at a time. This means, when one system is being activated and adjusted all other systems must be off.
5. Step V - Once all systems have been accurately adjusted, all systems would then be turned on and the operating potentials would be recorded. Although the operating potentials would have questionable accuracy they would serve as a basis of comparison for future long term system operations by WSDOT.
6. An annual survey should be performed by qualified personnel to assure continued proper operation of the installed system.

R.W. Beck

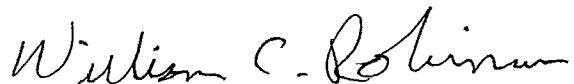
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October 1993

We appreciate the opportunity to assist R.W. Beck in this important project. If you have any questions or would like additional information regarding this report, please do not hesitate to contact our office.

Sincerely yours,

INTERMOUNTAIN CORROSION SERVICE, Inc.



William C. Robinson, P.E.  
President

WCR/vw

## **COST ESTIMATE**

The cost estimates below are referenced to the recommendations contained in this report.

<u>STEP</u>	<u>DESCRIPTION</u>	<u>MANHOURS</u>	<u>COST</u>
I.	Turn off each installed system.	WSDOT <sup>(1)</sup>	---
II.	Record native cable-to-water potentials for all installed cables at wall, 10' out, cable tunnel & PRC. Perform continuity testing.	2418	\$156,000
III.	Select, test, document seven representative cables.	404	\$25,000
IV.	Energize and adjust each installed system on the LVM and 3rd Bridge.	2139	\$140,000
V.	Final test and survey to be used as baseline for future testing.	1179	\$84,000

(1) WSDOT - work to be performed by WSDOT personnel.

ICS would be pleased to create a testing and maintenance manual for both of the I-90 bridges. The manual would document each of the installed systems and the testing to be performed by WSDOT personnel in terms of periodic maintenance. ICS would work closely with WSDOT personnel and would provide a one-day seminar for maintenance personnel. A total cost for a seminar and 10 copies of the manual is estimated at \$12,000.

**TABLE I**  
**Cathodic Protection Assessment**  
**Lake Washington - I-90 Bridges**  
**Individual Cable Testing**

Cable - To - Water Potential Data<sup>(1)</sup>

REFERENCE CELL LOCATION

LVM O-N	Rectifier	At Pontoon Wall				10' From Pontoon Wall			
		ON	OFF	△	ON	OFF	△	ON	OFF
<b>3RD BRG. RECT.</b>									
N-N	960	930	0	670	670	0	1090	1090	0
N-S	940	940	0	710	710	0	1090	800	290
O-N	920	920	0	750	750	0	1040	1040	0
O-S	960	960	0	710	710	0	1040	1040	0

LVM Q - N Cable

LVM Q-N	Rectifier	At Pontoon Wall				10' From Pontoon Wall			
		ON	OFF	△	ON	OFF	△	ON	OFF
<b>3RD BRG. RECT.</b>									
P-N	590	590	0	550	550	0	880	880	0
P-S	660	660	0	610	610	0	880	880	0

(1) Cable-to-Water Potential measured vs. Cu/CuSO<sub>4</sub> Reference Electrode placed a maximum of 12" from cable.



**TABLE II**  
**Cathodic Protection Assessment**  
**Lake Washington - I-90 Bridges**  
**Individual / Adjacent Cable Testing**

Cable - To - Water Potential Data (mV) <sup>(1)</sup>

REFERENCE CELL LOCATION									
LVM F-LN-1 Cable									
At Pontoon Wall									
ON							ON	OFF	OFF
Cycled Rectifier	ON	OFF	$\Delta$	ON	OFF	$\Delta$	ON	OFF	$\Delta$
3rd F-N	910	940	+30	470	510	+40	1330	1400	+70
3rd G-N	790	810	+20	450	450	0	1190	1190	0
3rd G-S	1000	1000	0	360	400	+40	1110	1110	0
LVM F-L5-N	640	640	0	400	400	0	1310	1270	40
LVM G-L3-N	650	680	+30	380	410	+30	1200	1200	0
PRC <sup>(2)</sup> - 314'							ON	OFF	OFF
LVM F-LN-1 Rectifier	ON	OFF	$\Delta$	ON	OFF	$\Delta$	ON	OFF	OFF
3rd F-N	1140	1130	-10	860	850	-10	1010	920	-90
3rd G-N	1000	1000	0	890	840	-50	900	900	0
3rd G-S	1090	1090	0	970	930	-40	1010	1010	0
LVM F-L5-N	1210	1210	0	1030	1030	0	1010	1010	0
LVM G-L3-N	1290	1290	0	990	990	0	1290	1290	0
PRC <sup>(2)</sup> - 542'							ON	OFF	OFF
Cycled Rectifier	ON	OFF	$\Delta$	ON	OFF	$\Delta$	ON	OFF	$\Delta$
3rd F-N	1140	1130	-10	860	850	-10	1010	920	-90
3rd G-N	1000	1000	0	890	840	-50	900	900	0
3rd G-S	1090	1090	0	970	930	-40	1010	1010	0
LVM F-L5-N	1210	1210	0	1030	1030	0	1010	1010	0
LVM G-L3-N	1290	1290	0	990	990	0	1290	1290	0

(1) Cable-to-Water Potential measured vs. Cu/CuSO<sub>4</sub> Reference Electrode placed a maximum of 12" from cable.

**TABLE III**  
 Cathodic Protection Assessment  
 Lake Washington - I-90 Bridges  
 Longitudinal Cable Testing

Cable - To - Water Potential Data (mV) <sup>(1)</sup>

REFERENCE CELL LOCATION LVM J-N Cable	At Pontoon Wall				10' From Pontoon Wall				
	LVM J-N	ON	OFF	ON	OFF	ON	OFF	ON	OFF
3rd Bridge Rectifier									
3rd I-N	1700	1700	0	810	810	0	1800	1800	0
3rd I-S	1640	1640	0	700	700	0	1860	1860	0
3rd J-N	1510	1510	0	890	890	0	1810	1810	0
3rd J-S	1610	1610	0	790	790	0	1890	1890	0
3rd J-L1-N	1410	1520	+90	590	710	+120	1710	1800	+90
3rd J-L2-N	1400	1400	0	610	610	0			
3rd J-L2-S	1520	1520	0	690	690	0	1710	1710	0
3rd J-L3-S	1500	1500	0	720	720	0			

- (1) Cable to Water Potential measured vs. Cu/CuSO<sub>4</sub> Reference Electrode placed a maximum of 12" from cable.  
 (2) PRC - Cable-to-Water Potential measured vs. permanently installed Ag/AgCl reference cell.

**TABLE III**  
**Cathodic Protection Assessment**  
**Lake Washington - I-90 Bridges**  
**Longitudinal Cable Testing**

Cable - To - Water Potential Data (mV) <sup>(1)</sup>

REFERENCE CELL LOCATION  
LVM J-N Cable

LVM J-N	PRC - 49 <sup>(2)</sup>				PRC - 87 <sup>(2)</sup>			
	ON	OFF	ON	OFF	ON	OFF	ON	OFF
<u>3rd Bridge Rectifier</u>								
3rd I-N	1410	1410	0	1060	1060	0	1840	1840
3rd I-S	1380	1380	0	1110	1110	0	1820	1820
3rd J-N	1400	1400	0	1000	1000	0	1810	1810
3rd J-S	1460	1460	0	1090	1090	0	1820	1820
3rd J-L1-N	1710	1810	+100	1000	1100	+100	2100	1900
3rd J-L2-N	1410	1410	0	970	970	0	2100	2050
3rd J-L1-S	1450	1420	-30	1090	1010	80	1890	1790
3rd J-L2-S	1420	1420	0	1080	1080	0	1620	1640
3rd J-L3-S	1500	1500	0	1120	1120	0	1940	1940
							0	1410
							690	710
							+20	+20
							1410	1410
							0	0

- (1) Cable to Water Potential measured vs. Cu/CuSO<sub>4</sub> Reference Electrode placed a maximum of 12" from cable.  
 (2) PRC - Cable-to-Water Potential measured vs. permanently installed Ag/AgCl reference cell.



**TABLE III**  
**Cathodic Protection Assessment**  
**Lake Washington - I-90 Bridges**  
**Longitudinal Cable Testing**

Cable - To - Water Potential Data (mV) <sup>(1)</sup>

REFERENCE CELL LOCATION  
 LVM J-N Cable

LVM J-N		PRC - 260 <sup>(2)</sup>					
		ON	OFF	△	ON	OFF	△
3Rrd Bridge							
J-N		1620	1620	0	1110	1110	0
J-S		1620	1620	0	1110	1110	0
J-N		1610	1620	+10	1040	1040	0
J-S		1600	1600	0	1060	1060	0
J-L1-N		1580	1580	0	970	970	0
J-L2-N		1620	1620	0	1120	1120	0
J-L1-S		1630	1630	0	1170	1170	0
J-L2-S		1610	1610	0	1080	1080	0

(1) Cable to Water Potential measured vs. Cu/CuSO<sub>4</sub> Reference Electrode placed a maximum of 12" from cable.  
 (2) PRC - Cable-to-Water Potential measured vs. permanently installed Ag/AgCl reference cell.

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**TABLE IV**  
**Cathodic Protection Assessment**  
**Lake Washington - I-90 Bridges**  
**End Pontoon Cable Testing**

Cable - To - Water Potential Testing (mV) <sup>(1)</sup>

REFERENCE CELL LOCATION  
LVM A - SE Cable

Structure Connection	At Pontoon Wall		
Cable A - SE	ON	OFF	Δ
Cycled Rectifier	665	645	20
A - SE	670	672	+2
A - SW			

REFERENCE CELL LOCATION  
LVM A - SW Cable

Structure Connection	At Pontoon Wall		
Cable A - SW	ON	OFF	Δ
Cycled Rectifier	790	780	+10
A - SE	820	820	0
A - SW			

(1) Cable-to-Water Potential measured vs. Cu/CuSO<sub>4</sub> Reference Electrode placed a maximum of 12" from cable.  
(2) PRC - Cable-to-water Potential measured vs. permanently installed Ag/AgCl reference cell.



TABLE IV  
Cathodic Protection Assessment  
Lake Washington - I-90 Bridges  
End Pontoon Cable Testing

Cable - To - Water Potential Testing (mV) <sup>(1)</sup>

REFERENCE CELL LOCATION  
LVM A - SW Cable

Structure Connection	At Pontoon Wall		
Cable A - SW	ON	OFF	△
Cycled Rectifier A - SW	820	820	0



(1)

Cable-to-Water Potential measured vs. Cu/CuSO<sub>4</sub> Reference Electrode placed a maximum of 12" from cable.

(2) PRC - Cable-to-water Potential measured vs. permanently installed Ag/AgCl reference cell.

**TABLE V**  
**Cathodic Protection Assessment**  
**Lake Washington - I-90 Bridges**  
**Cable Pair Testing**

Cable - To - Water Potential Testing (mV) <sup>(1)</sup>

REFERENCE CELL LOCATION  
 LVM Q - N Cable

Structure Connection	At Pontoon Wall			10' From Pontoon Wall		
Cable Q - N	ON	OFF	Δ	ON	OFF	Δ
LVM Rectifier Cycled	700	500	200	1000	730	270
Q - N	790	770	20			
Q - S						

REFERENCE CELL LOCATION  
 LVM Q - S Cable

Structure Connection	At Pontoon Wall			10' From Pontoon Wall		
Cable Q - S	ON	OFF	Δ	ON	OFF	Δ
LVM Rectifier Cycled	770	770	0	920	640	280
Q - N	750	700	50			
Q - S						

(1) Cable-to-Water Potential measured vs. Cu/CuSO<sub>4</sub> Reference Electrode placed a maximum of 12" from cable.

**TABLE V**  
**Cathodic Protection Assessment**  
**Lake Washington - I-90 Bridges**  
**Cable Pair Testing**

Cable - To - Water Potential Testing (mV) <sup>(1)</sup>

REFERENCE CELL LOCATION  
LVM Q - S Cable

Structure Connection	At Pontoon Wall			10' From Pontoon Wall		
Cable Q - N	ON	OFF	$\Delta$	ON	OFF	$\Delta$
LVM Rectifier Cycled	700	700	0	1100	850	250
Q - N	570	545	25	830	780	50
Q - S						

REFERENCE CELL LOCATION  
LVM Q - N Cable

Structure Connection	At Pontoon Wall			10' From Pontoon Wall		
Cable Q - N	ON	OFF	$\Delta$	ON	OFF	$\Delta$
LVM Rectifier Cycled	906	670	130	1100	850	250
Q - N	950	940	10			
Q - S						



(1)

Cable-to-Water Potential measured vs. Cu/CuSO<sub>4</sub>. Reference Electrode placed a maximum of 12" from cable.

**TABLE V**  
**Cathodic Protection Assessment**  
**Lake Washington - I-90 Bridges**  
**Cable Pair Testing**

Cable - To - Water Potential Testing (mV) <sup>(1)</sup>

REFERENCE CELL LOCATION  
 LVM O - N Cable

Structure Connection	At Pontoon Wall			10' From Pontoon Wall		
	ON	OFF	△	ON	OFF	△
LVM Rectifier Cycled	995	735	260		1040	780
O - N		990			260	
O - S						

REFERENCE CELL LOCATION  
 LVM O - S Cable

Structure Connection	At Pontoon Wall			10' From Pontoon Wall		
	ON	Off	△	ON	OFF	△
LVM Rectifier Cycled	810	810	0			
O - N		810				
O - S						

(1) Cable-to-Water Potential measured vs. Cu/CuSO<sub>4</sub>. Reference Electrode placed a maximum of 12' from cable.

**TABLE V**  
**Cathodic Protection Assessment**  
**Lake Washington - I-90 Bridges**  
**Cable Pair Testing**

Cable - To - Water Potential Testing (mV) <sup>(1)</sup>

REFERENCE CELL LOCATION		At Pontoon Wall			10' From Pontoon Wall		
		ON	Off	△	ON	OFF	△
LVM Rectifier Cycled		460	560	100			
O - N		460	420	40	570	515	55
O - S							
REFERENCE CELL LOCATION		At Pontoon Wall			10' From Pontoon Wall		
		ON	Off	△	ON	OFF	△
LVM Rectifier Cycled		1260	920	340			
O - N		1040	1040	0	1490	1160	330
O - S							

(1) Cable-to-Water Potential measured vs. Cu/CuSO<sub>4</sub> Reference Electrode placed a maximum of 12' from cable.

**TABLE V**  
**Cathodic Protection Assessment**  
**Lake Washington - I-90 Bridges**  
**Cable Pair Testing**

Cable - To - Water Potential Testing (mV) <sup>(1)</sup>

REFERENCE CELL LOCATION  
LVM O - N Cable

Structure Connection Cable O - N	At Pontoon Wall			10' From Pontoon Wall		
	ON	Off	△	ON	OFF	△
LVM Rectifier Cycled O - N	810	560	250			

REFERENCE CELL LOCATION  
LVM O - S Cable

Structure Connection Cable O - N	At Pontoon Wall			10' From Pontoon Wall		
	ON	Off	△	ON	OFF	△
LVM Rectifier Cycled O - S	2600	2130	470			

(1) Cable-to-Water Potential measured vs. Cu/CuS<sub>x</sub>. Reference Electrode placed a maximum of 12" from cable.

**TABLE VI**  
**Cathodic Protection Assessment**  
**Lake Washington - I-90 Bridges**  
**Individual Cable Testing**

Cable - To - Water Potential Testing (mV) <sup>(1)</sup>

REFERENCE CELL LOCATION  
LVM F-L2-N Cable

Structure Connection		At Pontoon Wall			10' From Pontoon Wall		
LVM Rectifier Cycled		ON	OFF	△	ON	OFF	△
F - L2 - N		600	200	400	1450	980	470
Structure Connection				Cable Barrel			
LVM Rectifier Cycled		ON	OFF	△	ON	OFF	△
F - L2 - N		660	450	210			

- (1) Cable-to-Water Potential measured vs. Cu/CuSO<sub>4</sub> Reference Electrode placed a maximum of 12" from cable.
- (2) Rectifier F-L2-N Output 13.2V @ 0.53 amps.
- (3) Rectifier J-N Output 23.5V @ 1.03 amps.
- (4) PRC - Cable-to-water Potential measured vs. permanently installed Ag/AgCl reference cell.

**TABLE VI**  
**Cathodic Protection Assessment**  
**Lake Washington - I-90 Bridges**  
**Individual Cable Testing**

**Cable - To - Water Potential Testing (mV) <sup>(1)</sup>**

**REFERENCE CELL LOCATION**  
LVM J-N Cable

Structure Connection		At Pontoon Wall			10' From Pontoon Wall		
LVM Rectifier Cycled	J - N	ON	OFF	Δ	ON	OFF	Δ
		1360	330	1330	1620	900	720
Structure Connection	J - N	PRC - 49 <sup>(4)</sup>			PRC - 187 <sup>(4)</sup>		
LVM Rectifier Cycled	J - N	ON	OFF	Δ	ON	OFF	Δ
		1960	1620	370	2000	1630	370
Structure Connection	J - N	PRC - 260 <sup>(4)</sup>					
LVM Rectifier Cycled	J - N	ON	OFF	Δ			
		1170	840	330			

- (1) Cable-to-Water Potential measured vs. Cu/CuSO<sub>4</sub> Reference Electrode placed a maximum of 12" from cable.  
 (2) Rectifier F-L2-N Output 13.2V @ 0.53 amps.  
 (3) Rectifier J-N Output 23.5V @ 1.03 amps.  
 (4) PRC - Cable-to-water Potential measured vs. permanently installed Ag/AgCl reference cell.

**TABLE VII**  
 Cathodic Protection Assessment  
 Lake Washington - I-90 Bridges  
 Continuity Testing / LVM Pontoon A

Cable - To - Water Data

REFERENCE CELL LOCATION  
Pontoon Wall, LVM A - SE Cable

<u>PONTOON</u>	<u>AREA</u>	<u>STRUCTURE</u>	<u>ON</u>	<u>Δ</u>	<u>POTENTIAL - mV<sup>(1)</sup></u>
A	SE	Cable - Used as Baseline	613 <sup>(2)</sup>	-	
	SW	Cable	611	2	
	SE	Cleat	611	2	
	SE	Electrical Conduit	566	47	
Center	10"	Pipe on Stanchions	610	3	
	SW	Cleat	611	2	
	Center	Cleat - Used as Baseline	650 <sup>(2)</sup>	-	
Center	Guard Rail Post		650	0	
	Ladder Post		650	0	
	S	Guard Rail Post	650	0	

(1) Cable-to-Water Potential measured vs. Cu/CuSO<sub>4</sub> Reference Electrode placed a maximum of 12" from cable.  
 (2) Used as basis to compare subsequent data.



TABLE VIII  
Cahtodic Protection Assessment  
Lacey V Murrow Bridge  
CP Rectifier Output Analysis

(TEST DATA SUPPLIED BY R.W. BECK)

<u>Cable ID</u>	<u>DC (Volts)</u>	<u>Current (Amps)</u>	<u>Length (Ft.)</u>	<u>Resistance (Ohms)</u>	<u>(mOhms) (Ft.)</u>	<u>(mAmps) (Ft.)</u>
ANW	14.0	0.60	445	23.3	52.4	1.34
ANE	15.0	1.10	460	13.6	29.6	2.39
ASW	10.6	0.75	365	14.1	38.7	2.05
BN	11.4	0.64	476	17.8	37.4	1.34
BS	1.0	0.52	435	1.9	4.4	1.21
CN	6.3	0.38	620	16.6	26.7	0.61
CS	21.3	2.32	553	9.2	16.6	4.20
DN	12.0	1.12	687	10.7	15.6	1.63
DS	40.0	4.19	488	1.0	1.9	8.63
EN	13.4	1.22	717	11.0	15.3	1.70
ES	39.0	4.09	615	9.4	15.2	6.65
FN	18.5	1.48	734	12.5	17.0	2.01
FS	18.0	1.24	635	14.5	22.9	1.95
F-L1-N	29.7	3.12	688	9.5	13.8	4.53
F-L1-S	30.4	2.88	686	10.5	15.3	4.19
F-L2-N	13.6	1.08	680	12.6	18.5	1.58
F-L2-S	18.0	1.42	680	12.7	18.6	2.08
F-L4-N	16.1	1.10	680	14.6	21.5	1.61
F-L4-S	35.0	3.20	680	10.9	16.1	4.70
F-L5-N	16.0	1.10	688	14.5	21.1	1.59
F-L5-S	25.4	2.28	688	11.1	16.2	3.31
G-N	8.3	0.50	763	16.6	21.8	0.65
G-S	12.9	1.10	635	11.7	18.5	1.73
G-L3-N	16.3	1.26	688	12.9	18.8	1.83



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TABLE VIII  
Cathodic Protection Assessment  
Lacey V Murrow Bridge  
CP Rectifier Output Analysis

(TEST DATA SUPPLIED BY R.W. BECK)

<u>Cable ID</u>	<u>DC (Volts)</u>	<u>Current (Amps)</u>	<u>Length (Ft.)</u>	<u>Resistance (Ohms)</u>	<u>(mOhms) (Ft.)</u>	<u>(mAmps) (Ft.)</u>
G-L3-S	34.8	3.42	688	10.2	14.8	4.97
G-L6-N	18.4	1.60	688	11.5	16.7	2.32
G-L6-S	13.2	1.0	688	13.2	19.2	1.45
H-N	13.6	1.20	750	11.3	15.1	1.60
H-S	13.6	1.18	635	11.5	18.6	1.86
I-N	28.1	2.90	733	9.7	13.2	3.95
I-S	28.0	2.90	635	9.7	15.2	4.56
J-N	23.7	2.22	692	10.7	2.4	3.21
J-S	13.9	1.10	635	12.6	19.9	1.73
K-N	8.2	0.50	634	16.4	25.9	0.78
K-S	28.5	2.94	622	9.7	15.6	4.73
L-N	28.5	2.94	588	9.7	16.5	5.00
L-S	39.6	4.23	609	9.4	15.4	6.95
M-N	23.3	2.45	501	9.5	19.0	4.89
M-S	25.4	3.57	612	7.1	11.6	5.83
N-N	6.9	0.46	402	15.0	37.3	1.14
N-S	11.9	1.52	544	7.8	14.3	2.79
O-N	6.4	0.26	312	24.6	78.9	0.83
O-S	15.8	1.75	463	9.0	19.5	3.78
P-N	21.3	1.52	299	14.0	46.9	5.08
P-S	6.4	0.43	424	14.9	35.1	1.01
Q-N	6.7	0.33	351	20.3	57.8	0.94
Q-S	24.9	1.77	424	14.1	33.2	4.17
R-N	7.3	3.20	420	2.3	5.4	7.61



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**TABLE VIII**  
**Cahtodic Protection Assessment**  
**Lacey V Murrow Bridge**  
**CP Rectifier Output Analysis**

(TEST DATA SUPPLIED BY R.W. BECK)

<u>Cable ID</u>	<u>DC (Volts)</u>	<u>Current (Amps)</u>	<u>Length (Ft.)</u>	<u>Resistance (Ohms)</u>	<u>(mOhms) (Ft.)</u>	<u>(mAmps) (Ft.)</u>
R-S	20.2	1.39	395	14.5	36.7	3.52
S-N	6.9	0.33	424	20.9	49.3	0.78
S-S	19.4	1.32	395	14.7	37.2	3.34
T-NW	9.3	0.74	474	12.6	26.5	1.56
T-NE	12.7	1.16	461	10.9	23.7	2.51
T-SE	5.9	0.24	430	24.6	57.2	0.56
T-SW	5.0	0.26	430	19.2	44.7	0.60